METRICS FOR THE TROPICAL OCEANS, WITH FOCUS ON THE TROPICAL PACIFIC

1 Climatologies

1.1 Annual Mean Statistics

Description of the annual mean structure of zonal currents, potential temperature and salinity in the upper 400 m of the equatorial Pacific have been greatly enhanced by the TAO mooring array maintenance cruises, by the Tropical Ocean Climate Study, WOCE, TOGA/COARE and WEPOCS cruises. Johnson et al. (2002) provides annual mean estimates of zonal currents, temperature and salinity, along an equatorial zonal section and across 10 meridional sections. McPhaden et al. (1998) provides estimates of long-term means and standard deviation for temperature along the equator and on four well-sampled XBT lines that have a near-meridional orientation. They also summarize published XBT-based transport estimates (relative to 400m) for the major upper ocean interior currents in the equatorial Pacific: the Equatorial Undercurrent (EUC), the South Equatorial Current (SEC), the South Equatorial Counter Current (SECC), the North Equatorial Current (NEC) and the North Equatorial Counter Current (NECC). The long-term mean dynamic height relative to 500 db is shown along the equator. Coles and Rienecker (2001) also summarize observational estimates of transport in these current systems and the New Guinea Coastal Undercurrent (NGCUC) and Mindinao Current (MC). Johnson et al. (2002) estimates the transports from ADCP data and according to the following isopycnal definitions:
EUC: all eastward flow between 2°N-2°S for potential densities of $23 < \sigma_\theta < 26.5$ kg m^{-3};
NECC: all eastward flow north of 2°N for $\sigma_\theta < 26.0$ kg m^{-3};
SEC(Northern branch): all westward flow between the equator and the NECC, for $\sigma_\theta < 26.0$ kg m^{-3};
SEC(Southern branch): all westward flow between 8°S and the equator for $\sigma_\theta < 26.0$ kg m^{-3}.

For GODAE, metrics for the validation of models and assimilation systems will be based on

- An Equatorial zonal section from 143°E to 95°W
- Meridional sections between 30°S-30°N; at 165°E, 155°W, 140°W, and 110°W
- Annual mean volume transport of the EUC, NECC, SEC, NGCUC, and MC.

References:

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- McPhaden, M.J. and co-authors: The Tropical Ocean-Global Atmosphere observing system: a decade of progress. *J. Geophys. Res.*, **103**, 14,169—14,240, 1998.

1.2 Seasonal variability

McPhaden et al. (1998) show the annual cycle of temperature and zonal currents in the upper 300m at 165°E, 170°W, 140°W, and 110°W on the equator. Yu and McPhaden (1999) add the seasonal variation of surface dynamic height, relative to 500 db, zonal current along the equator at 10m and 80m, and zonal sections of the depth of the 20°C isotherm and surface dynamic height at the equator, 5°N and 5°S. Johnson et al. (2002) provides estimates of the annual harmonic for zonal currents, transport of the EUC, SEC, and NECC, temperature and salinity, along an equatorial zonal section and across 10 meridional sections. The mean seasonal cycle of surface currents at 15 m in the equatorial Pacific between 20°S and 20°N is provided by Reverdin et al. (1994) on a 1°× 5° latitude-longitude grid. This product is a merger of surface drifter and moored current meter data from January 1987 to April 1992.

For GODAE, metrics for the validation of models and assimilation systems will be based on

- An Equatorial zonal section from 143°E to 95°W
- Meridional sections between 30°S-30°N; at 165°E, 155°W, 140°W, and 110°W
- Annual cycle at 165°E, 170°W, 140°W, and 110°W on the equator

Physical variables to be monitored are: monthly mean structure of zonal current, temperature and salinity in the upper 400m, heat content in the upper 300m and sea surface height and/or dynamic height.

- Annual cycle of volume transport in the EUC, NECC, and SEC.
- Annual cycle of currents at 15m, 20°S and 20°N.

References:

- Johnson, G.C., B.M. Sloyan, W.S. Kessler, and K.E. McTaggart: Direct measurements of the upper ocean currents and water properties across the tropical Pacific during the 1990s. *Progress in Oceanogr.*, **52**, 31-61,2002.
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2 Temporal variability

Temporal variability metrics should cover timescales from intraseasonal (20 days and longer) to interannual. The elements of the observing system available to validate model and assimilation analyses are limited to the tropical mooring arrays, tide gauges, surface altimetry and SST analyses. For GODAE, metrics for the validation of models and assimilation systems will be based on

- Pentads on an equatorial zonal section from 143°E to 95° and on meridional sections at 165°E, 155°W, 140°W, and 110°W between 8°S and 8°N. Physical variables to be monitored are

zonal current, temperature and salinity in the upper 400m, heat content in the upper 300m and sea surface height and/or dynamic height.

- Daily averages of temperature, currents, and surface height at TAO/Triton and PIRATA moorings
- Daily average of surface height and/or dynamic height (relative to 100 db) at selected tropical tide gauges

TAO/TRITON/PIRATA
The quality controlled data stream for the tropical moored buoy arrays is available from the TAO web site. The list of nominal sites, as well as other information, is available at http://www.pmel.noaa.gov/tao/proj_over/nominal.html .

Tide Gauge Data
The global database from tide gauges is accessible from the University of Hawaii Sea Level Center: http://uhslc1.soest.hawaii.edu/uhslc/fast.html. At minimum, the following locations should be monitored:
Rabaul: 4° 12′S, 152° 11′E
Kapingamarangi: 1° 6′N, 154° 47′E
Nauru: 0° 32′S, 166° 54′E
Betio: 1° 22′N, 172° 56′E
Kanton: 2° 49′S, 171° 43′W
Christmas: 1° 59′N, 157° 28′W
Baltra (Galapagos): 0° 26′S, 90° 17′W
Santa Cruz (Galapagos): 0° 45′S, 90° 19′W
Kwajalein: 8° 44′N, 167° 44′E
Penrhyn: 8° 59′S, 158° 3′W
Gan: 0° 41′S, 73° 9′E

3 Historical Interannual Variability

There are significant perturbations to the seasonal signal along the equator due to the influence of El Niño and La Niña events. These perturbations are evident, for example, in reversals of the equatorial undercurrent, in large displacements of the thermocline due to passage of equatorial waves, in displacements of the North Equatorial Countercurrent, and in large variations of subsurface salinity. Retrospective analyses will compare time series against the mooring data as above, and against the published literature.

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